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3 METHOD FOR INTRODUCING MERCURY INTO A
4 FLUORESCENT LAMP DURING MANUFACTURE
5 AND A MERCURY CARRIER BODY FACILITATING SUCH METHOD
6

7 CROSS-REFERENCE TO RELATED APPLICATIONS

8 This is a continuation-in-part of application Serial No.
9 10/308,943, filed December 3, 2002, in the name of Richard S.
10 Speer et al, and a continuation-in-part of application Serial No.
11 10/230,621, filed August 29, 2002, in the name of Richard S.
12 Speer et al.
13

14 BACKGROUND OF THE INVENTION

15 1. Field of the Invention

16 This invention relates to the manufacture of fluorescent
17 lamps and is directed more particularly to the introduction of a
18 limited amount of mercury into the lamp by way of a lamp exhaust
19 tubulation. The invention further relates to a carrier body for
20 placement in the lamp and which carries thereon a selected amount
21 of mercury to be admitted to the lamp.

22 2. Description of the Prior Art

23 Fluorescent lamps typically include at least one tubulation
24 which provides a conduit extending into the interior of the lamp
25 envelope and which, in construction of the lamp, is used as an
26 exhaust tubulation. At completion of manufacture, the exhaust
27 tubulation is hermetically closed.

1 Before sealing off of the exhaust tubulation open end, a
2 measured amount of mercury is introduced into the lamp. One of
3 the challenges facing lamp manufacturers is to minimize the
4 amount of mercury put into the lamp. It has been found difficult
5 to regulate the introduction of small amounts, such as nine
6 milligrams or less, of mercury.

7 There is thus a need for a method for introducing small
8 amounts of mercury into a fluorescent lamp. There is further a
9 need for a device which is structured to facilitate the
10 introduction of limited amounts of mercury and which is easily
11 handled in lamp manufacturing procedures.

12 13 SUMMARY OF THE INVENTION

14 An object of the invention is, therefore, to provide a
15 method for introducing a limited amount of mercury into an
16 envelope of a fluorescent lamp during manufacture of the lamp.

17 A further object of the invention is to provide a body for
18 placement in the lamp during manufacture, which body is adapted
19 to receive and retain only a selected amount of mercury and serve
20 as a carrier for the mercury introduced into the lamp.

21 With the above and other objects in view, a feature of the
22 present invention is the provision of a method for introducing a
23 limited amount of mercury into an envelope of a fluorescent lamp
24 during manufacture of the lamp. The method includes the steps of
25 forming the fluorescent lamp with an exhaust tubulation therein,
26 the exhaust tubulation being open at an end thereof, exhausting
27 the interior of the lamp envelope through the exhaust tubulation
28 open end, and placing a body of a metal material which does not

1 interact with mercury, in the lamp by way of the exhaust
2 tubulation open end. The body is provided with a coating of a
3 metal which amalgams with mercury, over a selected surface area
4 of the body, and is provided with mercury on the coated area of
5 the body, such that a limited and selected amount of the mercury
6 is retained on the body by the coating metal, and sealing the
7 open end of the exhaust tube. The amount of mercury retained on
8 the body is limited by the selected surface area of the coating
9 on the body.

10 In accordance with a further feature of the invention, there
11 is provided a further method for introducing a limited amount of
12 mercury into an envelope of a fluorescent lamp during manufacture
13 of the lamp. The method includes the steps of forming the
14 fluorescent lamp with an exhaust tubulation therein, the exhaust
15 tubulation being open at an end thereof and being provided with a
16 body retention structure proximate the open end, exhausting the
17 interior of the lamp envelope through the exhaust tubulation open
18 end, and placing a body of metal material not reactive with
19 mercury in the exhaust tubulation between the retention structure
20 and the exhaust tubulation open end. The body is provided with a
21 coating of a metal which amalgams with mercury, over a selected
22 surface area of the body, and is provided with mercury on the
23 coated area of the body, such that a limited and selected amount
24 of the mercury is retained on the body by the coating metal. The
25 method further comprises sealing the open end of the exhaust
26 tubulation. The amount of mercury retained on the body is
27 limited by the surface area of the coating on the body.

1 In accordance with a still further feature of the invention,
2 there is provided a method for introducing a limited amount of
3 mercury into a fluorescent lamp during manufacture of the lamp.
4 The method comprises the steps of forming the lamp with an
5 exhaust tubulation therein, the exhaust tubulation being open at
6 an end thereof, and exhausting the interior of the lamp through
7 the exhaust tubulation open end. The method further includes
8 providing a body of metal material not reactive with mercury, the
9 body being sized to enter the exhaust tubulation, electroplating
10 a coating of metal which amalgams with mercury over a selected
11 surface area of the body, and placing mercury on the coated area
12 of the body, such that a limited amount of mercury is retained on
13 the body by the metal coating, placing the body in the lamp by
14 way of the exhaust tubulation, and sealing the open end of the
15 exhaust tubulation.

16 In accordance with a still further feature of the invention,
17 there is provided a mercury carrier body for placement in a
18 fluorescent lamp during manufacture of the lamp. The carrier
19 comprises a body comprising a selected one of (i) a sphere and
20 (ii) a segment of wire, of a metal which does not interact with
21 mercury, a coating of a metal which amalgams with mercury,
22 disposed over a selected surface area of the body, and mercury
23 disposed on the metal coating and retained thereby in an amount
24 up to that permitted by the selected surface area of the metal
25 coating. The body thus carries into the lamp a selected amount
26 of mercury and is adapted for retention in the lamp after sealing
27 of the lamp at completion of manufacture.

1 The above and other features of the invention, including
2 various novel details of construction and combinations of parts
3 and method steps, will now be more particularly described with
4 reference to the accompanying drawings and pointed out in the
5 claims. It will be understood that the particular methods and
6 devices embodying the invention are shown by way of illustration
7 only and not as limitations of the invention. The principles and
8 features of this invention may be employed in various and
9 numerous embodiments without departing from the scope of the
10 invention.

11 12 BRIEF DESCRIPTION OF THE DRAWINGS

13 Reference is made to the accompanying drawings in which are
14 shown illustrative embodiments of the invention, from which its
15 novel features and advantages will be apparent.

16 In the drawings:

17 FIG. 1 is a diagrammatic sectional view of one type of
18 fluorescent lamp during manufacture thereof, and illustrative of
19 embodiments of the invention;

20 FIG. 2 is a sectional view of an exhaust tubulation portion
21 of the lamp of FIG. 1, the tubulation portion being shown with a
22 pinched portion for retention of a spherical body;

23 FIG. 3 is similar to FIG. 2, but further includes a mercury
24 carrier in the form of a spherical body resting on the pinched
25 portion;

26 FIG. 4 is similar to FIG. 3, but shows an end of the
27 tubulation closed off;

1 FIG. 5 is an enlarged side elevational view of an embodiment
2 of mercury carrier in the form of a sphere illustrative of an
3 embodiment of the invention;

4 FIG. 6 is a perspective view of an alternative embodiment of
5 mercury carrier in the form of a segment of wire;

6 FIGS. 7 and 8 are similar to FIG. 4, but showing the mercury
7 carrier of FIG. 6 disposed in the lamp tubulation portion;

8 FIG. 9 is a diagrammatic view showing another type of
9 fluorescent lamp;

10 FIG. 10 is similar to FIG. 3, but further including an
11 amalgam-carrying body in the tubulation portion; and

12 FIG. 11 is similar to FIG. 10, but shows the amalgam in a
13 melted condition.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, it will be seen that a known compact fluorescent lamp 10 is provided with a light-transmissive envelope 12 containing an ionizable gaseous fill for sustaining an arc discharge. In manufacture, the lamp 10 is dosed with the fill via an exhaust tubulation 14 in a known manner. A suitable fill, for example, comprises a mixture of a rare gas (e.g., krypton and/or argon) and mercury vapor. An excitation coil 16 is disposed within, and removable from, a re-entrant cavity 18 within the envelope 12. For purposes of illustration, the coil 16 is shown schematically as being wound about the exhaust tubulation 14. However, the coil 16 may be spaced apart from the exhaust tubulation 14 and wound about a core of insulating material (not shown), or may be free standing (not shown), as desired. The interior surfaces of the envelope 12 are coated in well-known manner with a suitable phosphor 20. In the type of lamp illustrated in FIG. 1, the envelope 12 fits into one end of a base assembly (not shown) containing a radio frequency power supply with a standard Edison type lamp base.

An indentation, or pinched portion 22 (FIG. 2), is disposed proximate a tip-off region 24 of the exhaust tubulation 14. The tip-off region 24 is the area at the free end of the exhaust tubulation 14 which is sealed, or "tipped off" to form the closed end 26 (FIG. 4) of the exhaust tubulation after evacuating the lamp therethrough.

After the lamp is evacuated through the exhaust tubulation 14, an appropriately sized and shaped metal ball 28, preferably of steel or steel alloy, is inserted into the exhaust tubulation

1 14 through an opening 30 at the tip-off region 24. By virtue of
2 the presence of the pinched portion 22 and the size and shape of
3 the ball 28, the ball remains on the side of the pinched portion
4 22 away from the re-entrant cavity 18. Finally, as noted above,
5 the exhaust tubulation 14 is tipped-off at a location proximate
6 the ball 28 to form the tubulation closed end 26.

7 In operation, current flows in the coil 16 as a result of
8 excitation by the aforementioned radio frequency power supply. A
9 radio frequency magnetic field is thereby established within the
10 envelope 12 which ionizes and excites the gaseous fill contained
11 therein, resulting in a toroidal discharge 32 (FIG. 1) and
12 emitting ultraviolet radiation therefrom. The phosphor 20
13 absorbs the ultraviolet radiation and emits visible radiation.

14 Referring to FIG. 4, it will be seen that in accordance with
15 the present invention there is provided the ball 28 disposed in
16 the glass tubulation 14 and retained by the pinched portion 22 of
17 the tubulation. In accordance with the invention, the ball 28
18 serves as a mercury carrier.

19 Referring to FIG. 5, it will be seen that the ball 28
20 comprises a sphere of metal, preferably steel or steel alloy. A
21 coating 34 of a metal is disposed on the ball 28. The coating
22 metal is a metal which amalgams with mercury, such as silver,
23 gold, indium, copper, and tin, and alloys thereof. The surface
24 area of the coating metal determines the amount of mercury which
25 will be retained thereby. The surface area may comprise the
26 whole of the surface area of the ball, or any portion less than
27 the whole of the surface of the ball, the latter being
28 illustrated in FIG. 5. If the selected surface area is less than

1 the whole, it is preferable that the coating be disposed in a
2 single patch on the surface of the ball.

3 Mercury 36 is applied to the metal coating 34. The metal
4 coating 34, by virtue of the selected surface area thereof, is
5 operative to retain a predetermined amount of the mercury. In
6 practice, amounts of mercury up to nine milligrams are readily
7 obtainable on a steel ball plated with silver, indium or gold and
8 having a diameter of three millimeters. As the diameter, and
9 thus the surface area of the ball, decreases the weight of the
10 mercury that can be carried is similarly reduced. A dose of
11 about 3-5 milligrams is commonly selected and easily supported by
12 the metal coating. The ball 28, with the coating 34 and mercury
13 36 thereon, is placed in the exhaust tubulation 14 and the open
14 end 30 of the tubulation is sealed, as at 26 (FIG. 4).

15 The ball 28 thus serves to accurately limit dosing of the
16 lamp with very small amounts of mercury, from about 9 milligrams
17 to well under 1 milligram. Further, as an additional benefit,
18 the coating 34 prevents the liquid mercury from depositing or
19 collecting in the lamp.

20 The ball 28 may be used in conjunction with one or more of
21 the usual glass balls for supporting an amalgam and/or for
22 spacing the ball 28 and/or amalgam balls in the exhaust
23 tubulation.

24 The ball 28 need not necessarily be disposed in the exhaust
25 tubulation 14. Rather, the ball 28 may be fed into the lamp
26 envelope 12 through the exhaust tubulation 14. In this
27 embodiment, the tubulation is not provided with the pinched
28 portion 22 prior to introduction of the ball, and the ball 28

1 enters the envelope and resides therein, as at 28' in FIGS. 1 and
2 9. The open end of the exhaust tubulation is thereafter pinched,
3 if amalgam balls are to be used, and thereafter closed.

4 Steel balls are well suited to serve as mercury carriers.
5 Steel does not interact with mercury, is inexpensive and is
6 readily available. In addition, the magnetic characteristic of
7 steel is an advantage in processing the balls during manufacture.
8 While steel is preferred, other metals which do not interact with
9 mercury are acceptable, such as nickel and various ferrous
10 alloys.

11 Referring to FIG. 6, it will be seen that in an alternative
12 embodiment the mercury carrier may be in the form of a metal wire
13 40, preferably of steel or steel alloy, but acceptably of any
14 metal not reactive with mercury. The coating 34 of a metal which
15 amalgams with mercury is disposed on the wire 40. As noted above
16 with respect to the metal ball carrier, the surface area of the
17 coating 34 determines the amount of mercury which will be
18 retained thereby, and the coating may be applied to a selected
19 area of the wire.

20 Mercury 36 is applied to the metal coating 34. Amounts of
21 mercury up to nine milligrams are readily disposed on the wire.

22 As shown in FIG. 7, the wire 40 may be placed in the lamp
23 exhaust tubulation 14 at the pinched portion 22 and retained
24 thereby. Alternatively, when using the wire 40 in a u-shaped
25 configuration, shown in FIG. 6, the springiness of the wire
26 retains the wire in the tubulation 14 without the need of a
27 pinched portion.

1 As in the case of the metal ball, the wire 40 may be
2 configured to simply pass through the tubulation 14 and enter the
3 lamp envelope 12 to occupy the position 28' shown in FIGS. 1 and
4 9.

5 In either embodiment, the metal carrier body 28, 40 accepts
6 electroplating of the coating 34, which facilitates the
7 application of very thin layers (.0001 - .0015 inch) of the
8 coating material.

9 Referring to FIG. 9, it will be seen that a further well-
10 known fluorescent lamp 10' is provided with an elongated tubular
11 light-transmissive envelope 12' containing ionizable gaseous fill
12 for sustaining an arc discharge. As in the case in the
13 embodiment of FIG. 1, in manufacturing the linear lamp 10' is
14 dosed with fill via an exhaust tubulation 14' in a known manner.

15 In accordance with the invention, after the lamp is
16 evacuated through the exhaust tubulation 14', the above-described
17 ball 28 is inserted into the lamp by way of the exhaust
18 tubulation. Thereafter, the exhaust tubulation is closed. Thus,
19 the ball 28, with the aforesaid coating 34 and mercury 36, is
20 enclosed in the envelope 12' of the lamp 10' and functions as a
21 mercury carrier, the same as in the lamp of FIGS. 1 and 9. In
22 the linear lamp 10' the exhaust tubulation 14' typically is not
23 provided with a pinched portion. Accordingly, the ball 28 passes
24 through the tubulation 14' and resides in the envelope 12', as at
25 28' in FIG. 9, without constraint other than the confines of the
26 envelope.

27 There are thus provided methods for introducing a selected
28 and limited amount of mercury into an envelope of a fluorescent

1 lamp during manufacture of the lamp. There are further provided
2 mercury carrier bodies in the forms of a ball and a segment of
3 wire for placement in the lamp during manufacture, and which are
4 adapted to retain the selected amount of mercury for dosing the
5 lamp.

6 Fluorescent lamps of both types mentioned hereinabove
7 typically contain a quantity of an amalgam, commonly located in
8 the exhaust tubulation and operative to reduce mercury vapor
9 pressure to permit optimum light output at elevated temperatures.
10 Such amalgams also provide a broadened peak in a light output
11 versus temperature curve, so that near optimum light output is
12 obtained over an extended range of temperatures.

13 The amalgams in use constitute alloys capable of absorbing
14 mercury from a gaseous phase. The alloys amalgamate with excess
15 mercury to regulate the mercury vapor pressure within the lamp.

16 When an amalgam fluorescent lamp is turned off, the amalgam
17 cools and the mercury vapor within the lamp is gradually absorbed
18 into the amalgam. When the lamp is turned on, the lumen output
19 is significantly reduced until the amalgam is warmed up to a
20 point at which the amalgam emits sufficient mercury vapor to
21 permit efficient lamp operation.

22 In some types of lamps, particularly electrodeless
23 fluorescent lamps, it is important that the amalgam be prevented
24 from settling within the arc environment in the lamp envelope
25 where the amalgam can cause deleterious changes in the lumen
26 output and the lumen-temperature performance of the lamp.

27 In base-up lamps (FIG. 1) there has been a particular
28 problem in that, in use, the sealed end of the tubulation is

1 pointed upwardly and the end of the tubulation that opens into
2 the lamp envelope is disposed downwardly of the amalgam. The
3 amalgam has tended to drop by gravity downwardly into the lamp
4 envelope, where a much higher temperature is present, causing a
5 sudden rise in mercury vapor pressure and an increase in lamp
6 voltage, resulting in the occurrence of black spots on the glass
7 envelope. If the lamp voltage exceeds the maximum sustaining
8 voltage of the ballast provided in the lamp, the lamp
9 extinguishes. There is thus required means for retaining liquid
10 amalgam in the tubulation, but permitting mercury vapor to exit
11 the tubulation and flow into the lamp envelope.

12 Referring to FIG. 10, it will be seen that the tubulation 14
13 may be provided with one or more of the balls 28 along with one
14 or more balls 42 carrying an amalgam 44, the amalgam supporting
15 balls 42 typically being of a glass construction.

16 When the amalgam 44 in the base-up lamp is liquidized, the
17 liquid amalgam tends to flow downwardly and, on occasion flows
18 around the glass balls 42 and into the lamp envelope. However,
19 with the coating 34 in place, the liquid amalgam 44 is attracted
20 to, and adheres to, the coating 34 (FIG. 11) and is thereby
21 prevented from moving further towards the lamp envelope.

22 Accordingly, the metal balls 28 described hereinabove serve
23 the further function of preventing liquid amalgam from entering
24 the lamp envelope in lamps of the type shown in FIG. 1.

25 In addition to the advantages of the invention set forth
26 hereinabove, the iron content of the steel bodies 28, 40 has been
27 found to improve results under a Toxicity Characteristic Leaching

1 Procedure (TCLP) prescribed on pages 26981-26998 of volume 55,
2 number 126, of the June 29, 1990 issue of the Federal Register.

3 Fluorescent lamps contain elemental mercury. During lamp
4 operation, chemical reactions take place that convert some of the
5 elemental mercury to salts or compounds, such as mercuric oxide,
6 that are water soluble. There is a concern that a waste stream
7 resulting from the disposal of fluorescent lamps may leach
8 excessive amounts of the soluble form of mercury. The method of
9 measuring the amount of soluble mercury which may leach from the
10 waste stream resulting from the disposal of fluorescent lamps is
11 described in the TCLP. According to the procedure, the lamp
12 being tested is pulverized into granules having a surface area
13 per gram of material equal to or greater than 3.1 cm² or having a
14 particle size smaller than 1 cm in its narrowest dimension.
15 Following pulverization, the granules are subjected to a sodium
16 acetate buffer solution having a pH of approximately 4.93 and
17 having a weight twenty times the weight of the granules. The
18 United States Environmental Protection Agency defines a maximum
19 concentration level for mercury at 0.2 milligram leachable
20 mercury per liter leachate fluid when the TCLP is applied.
21 According to the present standards, a fluorescent lamp is
22 considered nonhazardous when less than 0.2 milligram per liter of
23 leachable mercury results using the TCLP.

24 It has been found to be advantageous, with respect to the
25 TCLP, to provide an effective amount of a chemical agent within
26 the lamp suitable for electrochemically reducing a substantial
27 portion of the soluble mercury to elemental mercury when the lamp
28 is pulverized to granules and subjected to a suitable aqueous

1 acid solution. Preferably, the chemical agent is selected from a
2 group including iron.

3 The iron in the steel bodies 28, 40 is sufficient to
4 contribute to electrochemically reducing the amount of soluble
5 mercury within the lamp which is leached at the time of disposal
6 to less than 0.2 milligram per liter of the aqueous acid solution
7 prescribed by the TCLP.

8 The TCLP and the use of iron in the lamp to reduce soluble
9 mercury in the lamp is discussed in U.S. Patent No. 5,229,687,
10 issued July 20, 1993, in the names of Richard A. Fowler and
11 Robert P. Bonazoli, and is incorporated herein by reference.

12 Further, it is believed that the metal coating (silver,
13 indium or gold) on the body 28, 40 serves to collect soluble
14 mercury so as to leave little free soluble mercury in a discarded
15 lamp. Such can foreseeably obviate the need for conducting the
16 TCLP, it being necessary only to remove the body 28, 40 and
17 handle disposal of only the body, rather than the entire lamp
18 mass.

19 It will be understood that many additional changes in the
20 details, materials, steps and arrangement of parts, which have
21 been herein described and illustrated in order to explain the
22 nature of the invention, may be made by those skilled in the art
23 within the principles and scope of the invention as expressed in
24 the appended claims.